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ABSTRACT

Specific difficulties in mathematics tend to receive much less attention than do parallel difficulties with language. Accordingly, as its contribution to an ongoing project on children's learning difficulties and what to do about them, the Tayside (Scotland) Region decided to focus on children's specific problems with mathematics/arithmetic and the kinds of services that exist for such problems. The study attempted no direct measurement of pupil aptitudes but instead drew upon the perceptions and professional understandings of a group of Tayside secondary mathematics teachers who, in conjunction with the two directors of the main project, developed, implemented, and completed the study. Based upon these teachers' assessments, findings suggest that: (1) specific difficulties with mathematics do exist as an isolated entity; (2) these difficulties are functions of pupil attributes, perhaps inherent and relatively fixed, in interaction with the particular nature of mathematics; and (3) current practices and services can meet the needs of pupils with such difficulties to only a modest extent. Language difficulties were seen as a barrier that came between the pupil and mathematics in accessing the material, comprehending what was required, carrying it out, and communicating the results of the work. Appendices provide a review of the literature, with approximately 60 references; methodological considerations; and data gathering instruments. (JDD)

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ED 361 944

SPECIFIC LEARNING DIFFICULTIES

IN MATHEMATICS

Charles Weedon

DEPARTMENT OF EDUCATION
UNIVERSITY OF STIRLING
and
TAYSIDE REGION
August 1992

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Specific Learning Difficulties in Mathematics

ABSTRACT

This project, linked to the SOED-sponsored research 'Policies, Practice and Provision for Children with Specific learning Difficulties', focused upon the existence and nature of specific difficulties in Mathematics, and the kinds of provision that exist for such difficulties.

It attempted no direct measurement of pupil aptitudes. Instead, it accessed and drew upon the perceptions and professional understandings of those with experience both of the Mathematics curriculum and the responses of pupils to that curriculum - that is, those who teach Maths. At the same time, it explored cooperation between a research agency and practising classroom teachers, in that the study was developed, implemented and completed by a group of Tayside secondary teachers in conjunction with Stirling University's Professor Sally Brown and Dr. Sheila Riddell, project directors for the main part of the SOED project.

The findings, based upon teacher assessments and understandings of pupils' performances, suggest:

(i) that specific difficulties with Mathematics do exist as an isolatable entity;

(ii) that they are functions of pupil attributes, perhaps inherent and relatively fixed, in interaction with the particular nature of Mathematics;

and

(iii) that current practice and provision can meet the needs of pupils with such difficulties to only a modest extent.

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Tayside Region
May 1992

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Specific Learning Difficulties in Mathematics

1. The background

The research project 'Policies, Practices and Provision for Children with Specific Learning Difficulties' focuses mainly upon specific difficulties with language.

Tayside Region's involvement in the project sought to develop a research opportunity for teachers, while contributing at the same time to the project. A research focus was sought that could make an unambiguous and positive contribution to the main project, while retaining an identity separate enough to allow for its separate evaluation.

Specific difficulties with mathematics tend to receive much less attention than do parallel difficulties with language. Relatively little is known of their aetiology, incidence, or their co-occurrence and inter-relationships with language difficulties. Accordingly, it was decided that the Tayside contribution should explore such difficulties with mathematics/arithmetic.

A researcher was seconded from Tayside part-time, and the opportunity to participate as a teacher-researcher was offered to all the Region's secondary Maths and LS teachers. It was envisaged that the seconded researcher would share with each teacher-researcher a school-based case study.

The distinctive nature of this opportunity informed and directed both the research questions and the experimental design and methods. The main part of this report considers the research in terms of its contribution to the project. Appended is a consideration of the research in terms of its methodology, its links between a Regional Education Authority and a university-based research project, and the implications of combining a staff development opportunity for classroom teachers with their role as collaborators in a significant piece of research.

2. The research questions

It was decided that it would be inappropriate for a project of this nature to engage in direct psychological research - whatever the causes or precise nature of a specific difficulty, the educator's central concern is the ways in which a difficulty might manifest itself in the classroom, and how it might interact with the processes of learning.

Accordingly, it was decided to approach the topic by accessing the perceptions and professional understandings of those who teach Maths. Answers were sought to two questions:

1. Do teachers' perceptions of pupil difficulties suggest the existence of specific mathematical learning difficulties?

2. Does provision reflect these perceptions?

3. Literature review

A review that considers the sources of difficulty in Maths, the nature of 'mathematical ability', the relationships between difficulties in language and those in Maths, and the incidence of specifically mathematical difficulties, is contained in Appendix 1.

It reviews difficulties that might arise from social/ institutional factors, language-based difficulties, personality factors, and relevant hemispheric and neurological perspectives.

While it does indicate that there are learners whose difficulties tend to cluster around arithmetical and mathematical activities, it does not reveal significant evidence that might confirm developmental dyscalculia as a specific, separable, neurological condition. Fear of failure, poor educational practice, and preferred learning styles that are inappropriate to the distinctive nature of mathematical thought, all remain as contending explanations of school failure specific to Maths.

4. Design and Methodology

An obvious and perhaps the simplest means of gathering extensive pupil performance data is the paper-and-pencil group test. Much has been written about the validity, reliability and value of such sampling. In the circumstances of this project it was not seen as the most appropriate means.

As a data gathering technique, accessing teacher perceptions was seen as having a number of unique strengths that well outweighed the apparent precision of paper-and-pencil testing. Some of these are general points about testing in general, others are specific to this project:

(i) teacher perceptions draw upon long-term and typical performance, rather than providing single-episode analysis sometimes sampled in atypical conditions;

(ii) gathering perceptions allows simultaneous statement of performance along with a description of that performance and insights about its nature;

(iii) as a data gathering technique, it draws upon a considerable and relatively untapped source of information, experience and professional expertise

(iv) it allows for teacher involvement and ownership, encouraging an inherently valuable form of reflective research

(v) teacher perceptions are a factor of central importance:
- teachers are the arbiters of success, the main agents in defining it and attributing it;
- their perceptions structure and create the learning environment within which success occurs, or does not occur;
- they provide the mirror in which the pupil sees him or herself as a successful or unsuccessful learner.

Accordingly, the research questions were operationalised as follows:

1. Perceptions of maths difficulties:

(i) What leads a pupil to be perceived as poor in Maths? i.e. what constitutes a Maths difficulty, how is it conceptualised, and what criteria and evidence are used?

(ii) How are pupils described by Maths teachers as low Maths achievers perceived by teachers in other curricular areas?

(iii) Can discrete group(s) of pupils whose main locus of difficulty is mathematical be identified from comparison of these data?

(iv) If so, are there any patterns of common distinctive features among the ways in which the Maths difficulties of these pupils were perceived by their teachers?

(v) To what extent are pupil difficulties with Maths perceived to be a function of reading difficulties?

2. Provision for maths difficulties:

(i) How are low achievers in Maths catered for? Are they perceived of as a single homogenous population, and provided for in a uniform way, or is there different provision for different categories of difficulties?

Investigation focused on S1/S2 (12-13 year olds), as the curricular stage where pupils are exposed to the widest range of discrete curricular experiences.

The research questions themselves dictated the broad outline of each case study:

- a main interview schedule, for Maths and LS staff, focusing on Maths difficulties in general and those of specific pupils
  (i) to explore how teachers perceived and defined

difficulties in Maths

(ii) to identify specific pupils in that school deemed to have such Maths difficulties

(iii) for each such pupil, to reflect upon the nature of their difficulty with Maths;

- a subject teacher questionaire, to gather data about the success of these pupils in other parts of the curriculum;
- a questionaire for Principal Teachers of Mathematics about provision made for pupils with Maths difficulties.

The data gathering instruments were developed by the seconded researcher, in conjunction with the Stirling team. They are shown at Appendix 4.

5. The pilot trial

The data gathering instruments were piloted at Perth Grammar School, leading to some modifications to both research design and the instruments.

The main interview schedule: this was piloted by the seconded researcher with both Maths and LS colleagues. After discussion with the Stirling team, a number of amendments were made. These amendments had implications for the subject teacher questionaire, which was accordingly amended at this stage.

The amended main schedule was then further piloted, this time by Maths and LS staff with further of their own colleagues. No further amendments were indicated.

Six Maths/LS teachers were involved, leading to investigation of twenty eight identified S1/2 pupils.

In light of pilot trial experience, it was decided not to record the interviews. Piloting explored both recorded and unrecorded interviews. Staff involved tended to feel more comfortable without recording, and rather than impeding the interviews, the making of notes appeared to allow the interviewees the time and freedom to reflect and marshal their thoughts.

Initially the focus was on the mathematically least successful pupils only. Teachers were asked to consider the two or three least successful in each of their S1 and S2 classes. However, it was found that some teachers wanted to talk as well of other pupils they felt to be underperforming badly in Maths. As this seemed both feasible and appropriate, the schedule wording was amended accordingly to include such pupils.

6. Implementing the research

Initial interest was expressed by staff in twenty-one secondary schools across the Region, and data finally received from seventeen. Sixty one Maths teachers and twenty one LS teachers were interviewed by their teacher-researcher colleagues, and cross-curricular performance data gathered on three hundred and forty one pupils perceived as having difficulties in Maths.

(The project seeks only to consider the likely existence and possible nature of specific Maths difficulties - it does not explore their incidence, or seek a comprehensive identification of all pupils with Mathematical difficulties in the classes considered. It is, however, worth setting these figures into an approximate quantitative context: judging from the number of classes identified by teachers responding to interview, it can be assumed that the three hundred and forty one pupils, the pupils who came to mind for these teachers when asked to consider pupils in their classes with Maths difficulties, were identified from an population of between two and three thousand S1 and S2 pupils.)

Ten teacher researchers continued their involvement in the research, sharing in processing the data, and contributing to the final report. The nature and mechanics of this involvement are described in Appendix 2.

7. Results and discussion

The two central research questions were operationalised into further separate investigative strands. For ease of consideration, the following sections present together the results and discussion for each strand.

7.1 Teachers' perceptions of difficulties in Maths

7.1.1 Interview analysis scheme

Because the interview schedule presented open-ended questions to teachers, an analysis scheme was needed to categorise and analyse their responses. This was derived by reading and re-reading a sample of the interview notes, noting patterns and categories and constantly refining them until all comments and perceptions fell comfortably within the emerging categories. This was done by the seconded researcher, then adapted according to the comments of teacher-researchers. A number of minor refinements were made to the scheme during extraction of data.

The scheme used ten main groupings of factors:

- structural factors intrinsic to the nature of Maths (e.g. its inherent linearity)
- factors stemming from language/symbolic features (e.g. basic literacy difficulties, the use of mathematical symbols)
- factors stemming from particular qualities/skills needed for Maths (e.g. coping with the abstract, logical thinking)
- factors stemming from general qualities/skills needed for Maths (e.g. memory, the ability to organise one's own learning)
- factors apparently deriving primarily from personality traits (e.g. maturity, concentration, self esteem)
- motivational factors (e.g. frustration, parental attitudes)
- methodological factors (e.g. inappropriate materials or methodologies)
- other factors stemming from schools and/or teachers (e.g. bad classroom behaviour, poor teaching)

- factors stemming from pupils' past experiences (e.g. frequent absence)
- medical factors.

Except for the last, each main category consisted of a number of factors, sometimes as many as ten. This provided quite a finely-textured analytical scheme, and some of the categories were later merged to allow the broader underlying patterns to emerge with greater clarity.

Because the resulting scheme was very comprehensive, doubt during coding rare. ('Articulate poison dwarf' caused a moment's hesitation before being charitably coded as a 'preferred learning style unsuited to Mathematics'!)

Inevitably, there was potential overlap between coding categories, and there were cases where the analyst had to make a subjective judgment about category, taking into account the context and adjacent interview comments

Similarly, and throughout, apparently separate factors may be hierarchically linked, so that factors mentioned separately are to some extent manifestations of the same phenomenom. For example, inadequate application might STEM FROM a lack of ability to cope with the abstract and non-physical, and might LEAD TO frequent absence, which in turn might LEAD TO lack of access to prerequisite basic skills. While one teacher might mention most or all of these, another might mention only some. The factors mentioned by teachers represent those features that most immediately sprang to mind when the pupil was being considered - they do not necessarily comprise a comprehensive description

7.1.2 Interview responses: perceptions of the nature of pupils' difficulties

These are summarised in Table 1 below. The first two columns show the number of teachers who mentioned a particular factor. The interview first explored teachers' perceptions of difficulties in general, asking them why Maths might be a difficult subject for some pupils. The first column shows these responses, the number of teachers who mentioned each factor while reflecting about difficulties in general.

Then teachers identified and considered specific pupils in their own classes, and reflected upon the apparent reasons for the difficulties in each case. The second column shows these responses, the number of teachers who mentioned each factor while reflecting about specific learners.

This parallel presentation of data allows inspection of the ways in which perceptions shift as teachers move from general considerations to the consideration of specific individuals.

The final column shows the number of pupils described as being influenced by each factor.

Following Table 1, Table 2 summarises the data into the main groupings used, and Table 3 summarises it still further, considering the perceptions in three main categories: difficulties arising from the nature of the subject, pupil-based difficulties, and those caused by schools

TABLE 1

Summary of data from the interview responses

N(staff) = 82 (61 Maths staff, 21 LS staff)

N(pupils) = 341

(Note: The 341 pupils were those for whom full cross-curricular data was gathered. There was a further small number of pupils who were discussed by teachers during interview, but for whom insufficient data was returned by other subject teachers. They are included in the data below, but were not considered when screening the population for evidence of specific difficulties in Maths. Also, there is a small number of pupils in the data below who were discussed by both a Maths teacher and an LS teacher. As this first part of the study focuses only on teacher perceptions, it was deemed useful to include both sets of perceptions at this stage.)

FACTOR	TEACHERS MENTIONING THIS FACTOR		ATTRIBUTIONS OF THIS FACTOR TO SPECIFIC PUPILS
	in general	when considering specific pupils	
STRUCTURAL FACTORS INTRINSIC TO THE NATURE OF MATHS			
linear subject, where progress depends upon mastery of preceding work	28	7	7
difficulties and weaknesses cannot be sidestepped	2	-	-
intrinsically difficult subject: progress generally involves increasing difficulty, and S1 is the eighth year of Maths study	9	-	-
memorising facts/rote learning not enough	5	-	-
intrinsically different from other subjects in the nature and range of the skills needed	4	-	-
demands particular clarity and precision of thought	4	1	1

FACTOR	TEACHERS MENTIONING THIS FACTOR in general	when considering specific pupils	ATTRIBUTIONS OF THIS FACTOR TO SPECIFIC PUPILS
FACTORS STEMMING FROM LANGUAGE/ SYMBOLIC FEATURES			
naturally immersed in words, less so in numbers	4	-	-
lack of literacy skills	14	42	75
extracting the problem from the written text	6	7	10
difficulties with language and symbols	20	18	24
FACTORS STEMMING FROM PARTICULAR QUALITIES/SKILLS NEEDED FOR MATHS			
lack of access to prerequisite number skills & basic concepts	18	42	107
inability to cope with the abstract and non-physical	34	7	11
inability to recognise the skills needed, and to transfer and apply them to new contexts	9	11	19
lack of aptitude with reasoning and logical thought	13	10	11
lack of perceptual/spatial ability /confidence with shape	10	10	13
lack of readiness to assimilate new concepts or certain concepts	1	14	23
lack of mathematical ability	5	1	1
lack of mental arithmetic aptitude	1	1	2
lack of ability to learn/use rules	1	-	-
lack of the concept of number	5	9	13

FACTOR	TEACHERS MENTIONING THIS FACTOR in general	when considering specific pupils	ATTRIBUTIONS OF THIS FACTOR TO SPECIFIC PUPILS
FACTORS STEMMING FROM GENERAL QUALITIES /SKILLS NEEDED FOR MATHS			
inadequate memory	12	29	45
general lack of ability	6	28	53
lack of manual dexterity /equipment skills/motor skills	2	6	7
lack of metacognitive aptitude: i.e. readiness to monitor performance and apply common sense	-	6	6
inadequate organisational skills	-	9	11
inability to follow instructions	-	9	9
FACTORS APPARENTLY DERIVING PRIMARILY FROM PERSONALITY TRAITS			
lack of sufficient maturity	1	12	14
rushed/impulsive working style	2	10	13
inability to concentrate	3	37	59
inadequate application	3	13	23
inability to work at adequate speed	2	31	53
lacking confidence/ anxious/over cautious	4	42	73
fear of failure and low self esteem	8	12	15
deterred by right/wrong nature of Maths	6	1	1
lack of readiness to ask for help	-	15	18
preferred learning style unsuited to Maths	3	6	6
let down by poor test results	-	4	5

FACTOR	TEACHERS MENTIONING THIS FACTOR		ATTRIBUTIONS OF THIS FACTOR TO SPECIFIC PUPILS
	in general	when considering specific pupils	
MOTIVATIONAL FACTORS			
behavioural/motivational problems stemming from mathematical frustration/lack of ability	18	14	19
behavioural/motivational problems stemming from factors not directly mathematical	1	10	17
behaviour/motivational problems, reasons unspecified	3	17	25
negative perceptions: Maths unpopular; socially acceptable to be bad at Maths; effect of existing perceptions (from schools, parents and society)	29	-	-
negative reaction to excessive parental expectation	-	1	1
perceived irrelevance: remote from the everyday; difficult to make interesting/intrinsically boring	18	9	13
METHODOLOGICAL FACTORS			
class organisation/methodologies inappropriate	8	-	-
excessive use of individualised schemes/lack of direct teaching	2	-	-
inappropriate materials/courses	3	1	2
demands pitched too high/ curriculum too demanding	11	5	12
overemphasis on techniques at expense of understanding	4	3	3
too little practical/concrete work	5	1	1
inadequate early teaching	9	4	4
too little reinforcement/ practice	3	-	-

FACTOR	TEACHERS MENTIONING THIS FACTOR		ATTRIBUTIONS OF THIS FACTOR TO SPECIFIC PUPILS
	in general	when considering specific pupils	
OTHER FACTORS STEMMING FROM SCHOOLS AND/OR TEACHERS			
learning hindered by peer group attitudes/classroom behaviour	1	2	2
poor teacher training and/or teaching	4	-	-
lack of teacher time available to address individual's problems	5	4	6
lack of adequate resources	1	-	-
FACTORS STEMMING FROM PUPILS' PAST EXPERIENCES			
frequent absence	2	20	32
unsettled earlier schooling	1	9	11
MEDICAL FACTORS	-	12	15

TABLE 2

Summary of the data into its main groupings

N(staff) = 82 (61 Maths staff, 21 LS staff)

N(pupils) = 341

FACTOR	TEACHERS MENTIONING FACTORS IN THIS CATEGORY in general	when considering specific pupils	ATTRIBUTIONS OF FACTORS IN THIS CATEGORY TO SPECIFIC PUPILS
STRUCTURAL FACTORS INTRINSIC TO THE NATURE OF MATHS	52	8	8
FACTORS STEMMING FROM LANGUAGE/ SYMBOLIC FEATURES	44	67	109
FACTORS STEMMING FROM PARTICULAR QUALITIES/SKILLS NEEDED FOR MATHS	97	105	200
FACTORS STEMMING FROM GENERAL QUALITIES /SKILLS NEEDED FOR MATHS	20	87	130
FACTORS APPARENTLY DERIVING PRIMARILY FROM PERSONALITY TRAITS	32	183	280
MOTIVATIONAL FACTORS	69	51	75
METHODOLOGICAL FACTORS	44	14	22
OTHER FACTORS STEMMING FROM SCHOOLS AND/OR TEACHERS	11	6	8
FACTORS STEMMING FROM PUPILS' PAST EXPERIENCES	3	29	43
MEDICAL FACTORS	-	12	15

TABLE 3

Summary of the data into three main categories:

subject based: structural factors intrinsisc to the nature of Maths
pupil based: language skills, general and mathematical skills/qualities needed, personality, motivation, past experience and medical
school based: methodological, and other factors caused by schools/teachers

N(staff) = 82 (61 Maths staff, 21 LS staff)

N(pupils) = 341

FACTOR	TEACHERS MENTIONING FACTORS IN THIS CATEGORY		ATTRIBUTIONS OF FACTORS IN THIS CATEGORY TO SPECIFIC PUPILS
	in general	when considering specific pupils	
DIFFICULTIES ARISING FROM THE NATURE OF THE SUBJECT	52	8	8
PUPIL-BASED DIFFICULTIES	265	534	852
DIFFICULTIES CAUSED BY SCHOOLS	55	20	30

7.1.3 Discussion of teachers' perceptions

As shown in Table 3, teachers tend to see Maths difficulties as predominantly and unequivocally pupil-based. When considering difficulties in general, they attribute some responsibilty to the intrinsic nature of Maths and some to what happens in the schools; but they see these factors as comprising only a modest contribution to Maths difficulties, and their role diminishes still further once the attention of teachers turns to specific pupils. (The inter-relationships between these groups of factors are discussed in more detail in Section 7.2.3).

Throughout, there tends to be this clear shift of emphasis as teachers move from considering difficulties in general to considering difficulties in relation to specific pupils: the locus of responsibility moves decisively towards the pupil, and away from the school and the nature of the subject.

To some extent this is probably inevitable: the root cause of a difficulty may be identified when teachers reflect in general terms (column 1), but may then manifest itself in individual pupils in various ways, and it is these secondary manifestations that will occupy the teacher's attention when considering difficulties in relation to specific pupils (column 2).

The raw data does not attempt to distinguish between root cause and secondary manifestation. Categories overlap and interpenetrate - for example, if a pupil experiences difficulties due to absences or gaps in their earlier schooling, that may be attributed to the linear nature of Maths, and thus be intrinsic to the subject; or it may be attributed to lack of basic skills, a pupil-based difficulty; or it may be seen as arising from an inappropriate methodology or course, and thus caused by the school. No attempt is made to unravel these links in presenting the data. The data represents teachers' perceptions, and is presented accordingly, regardless of ultimate causality. But the data leaves little doubt about teachers' perceptions of the immediate locus of responsibilty: most explanations of difficulty are located within and about the individual pupil - a pupil-deficit model of learning difficulties.

Table 2 provides easiest access to the overall patterns. When difficulties in general are being considered, Table 2 shows that teachers give most emphasis to the kind of skills and qualities needed for Maths, with motivational factors ranking second, and then, clustered together, the nature of Maths, language factors and school-based factors.

When moving on to individual pupils, Table 2 shows how the skills and qualities needed for Maths are seen as remaining important, but that the pupil's own nature, learning style and personality has moved from a low ranking position to become decisively the most significant single feature. General intellectual qualities and language difficulties also become relatively more noticeable, while motivation is mentioned less often.

When attributing specific factors to identified pupils (column 3 in each table), Table 2 shows how learning style/personality-based factors are the most frequently used.

Table 1 allows closer analysis of perceived causes, and how they shift as teachers move from the general to the particular. It shows that the linear nature of Maths received some attention when teachers were reflecting in general, as did reading deficits and difficulties with symbols. Most of these reading and language difficulties tended to move forward in teachers' minds when they turned to individual pupils.

Similarly, a perceived lack of the necessary basic skills and concepts rose sharply as teachers moved from general considerations to specific pupils: it was attributed to 107 separate pupils, making it the most commonly applied description. The other factors most frequently used to describe pupils were lack of reading skills (75 descriptions), anxiety/lack of confidence (73 descriptions), inability to concentrate (59 descriptions), a general lack of ability and inadequate speed of working (both at 53 descriptions), and an inadequate memory (45 descriptions). All of these pupil-based factors were mentioned much more frequently than teachers' initial general reflections might have suggested. Conversely, the abstract nature of Maths was mentioned by 34 teachers when reflecting in general terms, but much less often in relation to specific pupils.

Overall then, and probably inevitably, teachers' inclination towards a pupil-deficit model became more marked the more closely they focused upon specific pupils. However, even without this trend, it is clear that most teachers feel that most of the reasons for Maths failure relate to the pupil.

Courses, methodologies, materials and teachers do receive their share of criticism (see Section 7.4 for fuller discussion). In particular, while the flexibility of individualised schemes is recognised, they are much criticised for the lack of direct teaching they provide, and the lack of discussion and shared exploration/group experience that they necessitate. Teachers involved with individualised courses regret the need for learning

to depend upon reading skills that are often limited among pupils with difficulties; further, they comment upon the relative inability of many such pupils to work independently and in isolation, necessary features of individualised learning. Whole-class teaching of mixed ability classes from a class text, however, aroused strong negative comment, and was seen by teachers as a source of hopelessness, frustration and anxiety.

The evidence suggests that teachers see the pupil's own attributes - intellectual, mathematical and personal - as being at the centre of mathematical difficulties. There is a clear sense that these qualities have already determined success or failure long before the child reaches the eighth year of study in this area. After that, despite the best efforts of teachers, and despite the range of methodologies and organisational approaches employed, the linear nature of the subject and its inherent abstraction and difficulty set in motion a down-cycle of failure and decreasing expectation, on the part of pupils, parents and teachers.

All in all, and quite strikingly, there is little indication of any widespread fundamental optimism: the responses are pervaded by a sense that these pupils are engaged in studying a subject where their relatively poor performance probably reflects their potential as mathematicians.

7.2 Distinctive features of pupils with difficulties specific to Maths

Twin insights were sought into the existence/nature of any difficulties specific to Maths: firstly, from general perceptions culled from the main interviews, the perceptions of those who teach Maths; and secondly, a more detailed analysis of the descriptions of any pupils whose cross-curricular performance indicated any weakness specific to Maths.

7.2.1 Teacher perceptions of specific difficulties with Maths culled from the main interviews

During the main interviews, teachers were asked if they thought there may be a mathematical syndrome that paralleled dyslexia - that is, a level of mathematical or arithmetical ability relatively and inexplicably a lot lower than that displayed in other areas of the curriculum. Table 4 shows their responses.

TABLE 4: Teachers perceptions of difficulties specific to Maths

N = 82

	DON'T KNOW OR NO COMMENT MADE	NO	YES
Number of teachers	19	20	43

As can be seen, the majority of teachers did feel that such a syndrome might exist. Those indicating a belief that there might be such a syndrome were asked to explain their belief. Some responded by explaining why they believed it. These responses fell into three broad categories.

Firstly, the everyday phenomenom of intelligent people, often highly educated and successful, claiming - even boasting of - difficulties with Maths.

Secondly, insights derived from their experience as teachers. They spoke of pupils who performed well in English but were very unsuccessful in Maths; of generally capable pupils apparently unable to grasp certain mathematical concepts; and of repeated problems among sometimes clever pupils.

The different forms specific difficulties might take were touched upon here: teachers spoke of pupils experiencing significant difficulty with all number work, while coping well with other aspects of Maths; and of pupils who get Higher Maths having failed 'O' grade Arithmetic.

The third category drew upon a sense that that was no reason to assume otherwise, a belief that the kind of neural malfunctions implied in dyslexia were likely to have a parallel in Maths; that, as one teacher phrased it, if word blindness exists, why not number blindness?

Other teachers, however, explained not *why* they believed its existence likely, but reflected instead about its nature, its manifestations, and its possible aetiology. Again, these responses fell into groups: those that saw specific Maths difficulties as a social function (and thereby presumably avoidable); and those whose reflections drew upon fixed characteristics and intellectual qualities of the pupil (and thus presumably more stubbornly resistant to intervention).

This latter group subdivided into some fairly general reasons, followed by explanations based on:

(i) difficulties arising from the abstract nature of Maths
(ii) memory-based defects;
(iii) spatial factors
(iv) neurological factors
(v) arithmetical/number-based difficulties

Firstly, the explanations drawing upon social/attitudinal factors. Many teachers commented upon the myths surrounding Maths, the expectation of difficulty sometimes handed down through families, and sometimes encouraged too by teachers. Many teacher who confirmed their belief in difficulties specific to Maths suggested they arose mainly from these factors: a lack of confidence deriving from social attitudes, perhaps reinforced by negative early experience. Several spoke of a 'psychological block' that precluded the development and deployment of abilities well within the range of the failing learner. Lack of confidence and fear of failure were seen as combining with the remorselessly linear nature of Maths to create the kinds of difficulties that might well not be found elsewhere in the curriculum. One teacher spoke of this as an 'aversion syndrome', based on low expectations. Another, a Principal Teacher of Maths, even spoke of a stigma attached to *success* in Maths.

Some suggestions could not be dichotomised into a 'social vs. intrinsic to the pupil' framework. For example, one teacher commented on a gender effect, with girls being more likely to do well in other subjects while badly in Maths. Many, however, saw specific difficulties as stemming quite clearly from factors intrinsic to the pupil. Some of these were fairly general: for example, that patterns of strengths and weaknesses occur across all subjects, so difficulties might be found apparently specific to any subject.

Some saw specific difficulties as stemming from the abstract nature of Maths: an innate difficulty with the abstract; difficulty in handling concepts and relating them to experience; and difficulties stemming from mathematical use of signs and symbols.

Memory-based deficits were quite frequently mentioned, and in particular deficits with the sequential memory. Poor long term storage of mathematical routines was also put forward as a cause of specific difficulties.

Difficulties specific to spatial and visual skills were seen by many as a decisive and distinctive source of specific disability, perhaps linking to the next category, those teachers seeing a neurological explanation of specific difficulties. These drew upon hemispheric considerations: it was suggested that preference/lack of dominance might well have a marked adverse effect of certain activities typical to Maths.

The most important single category, however, was those teachers who spoke of number-based difficulties: specific difficulties concerned with the concept of number and its manipulation. One of the first interviewees held decisively to the view, quite widely reflected among Maths teachers, that "Arithmetic is harder than Maths, and quite different - ye canny or ye can". These teachers spoke of an intrinsic confusion with numbers; of a lack understanding of their meaning, and relationships to one another; and of psychological blocks that precluded recognition of their nature and the patterns they represent. Given such fundamental confusion, successful manipulation of number, consistent and

successful use of the basic number operations, becomes highly unlikely. Difficulties with place value were frequently mentioned in this context, though some felt that this stemmed as much from difficulties with visual and spatial organisation.

7.2.2 Specific Maths difficulties revealed by the cross-curricular performance of pupils unsuccessful at Maths.

Cross-curricular performance of pupils with Maths difficulties was investigated by asking subject staff to describe performance according to the following criteria:

5 excellent (definite potential Credit level)
4 above average (probable Credit/good General level)
3 average (probable General level)
2 has some difficulty (probable Foundation level)
1 has considerable difficulty (Foundation level or No Award)

While it is recognised that any prediction of later performance has to be tentative, the Standard Grade comparisons were used as a useful way of providing a common reference point. It is recognised too that these measures are both crude and subjective; they are regarded as useful, however, for reasons similar to those discussed earlier, in Section 4 (page 2).

There were no precise criteria for identifying specific Maths difficulties from the resulting cross-curriculum data - instead, a consensus of informed practitioners was sought. Seven teacher-researchers examined the data, having been asked to identify those pupils whose cross-curriculum profiles showed any significant discrepancies that might indicate a relative weakness in Maths or related areas.

This yielded thirty-six names, though some were regarded by the identifying teachers as being very tentative. To provide a more rigorous criterion, it was deemed that a profile must be identified by four or more teacher-researchers. The fourteen resulting profiles are shown below, in Table 5, parts (i) to (v).

They are arranged by the extent of their difficulty in Maths, combined with the extent of the discrepancies with their performance elsewhere, as follows:

Table 5 (i):

major Maths difficulties, and major discrepancies with other subject areas

Table 5 (ii):

major Maths difficulties, and more modest discrepancies with other subject areas

Table 5 (iii):

moderate Maths difficulties, and major discrepancies with other subject areas

Table 5 (iv):

moderate Maths difficulties, and more modest discrepancies with other subject areas

Table 5 (v):

average Maths performance, but significantly lower than in other subject areas

TABLE 5: Profiles of pupils with relative difficulties apparently specific to Maths and related areas

Table 5 (i): major Maths difficulties, and major discrepancies with other subject areas

Pupil No. 1

Comments on Maths performance:

- No Award or a Foundation in Maths - has considerable difficulty
- hung up on negative number - conceptual blockage - everything needs to be broken down into the smallest steps - nice girl and good attitude but needs endless help - lack of confidence in English - the underlying meanings of the questions not clear to her. Meticulous, and takes pride in appearance of her work - confident socially, but not mathematically: "I can't do that"

Cross-curriculum predicted future performance levels:

a probable Credit in PE
a probable Credit/good General in Technical
good Generals in Modern Languages and History
probable Generals in Science and Geography
borderline General/Foundation in Modern Studies, Home Economics and Music
probable Foundations in English and Art

Pupil No. 2

Comments on Maths performance:

- No Award or a Foundation in Maths - has considerable difficulty
- cannot grasp concepts - lacks understanding

Cross-curriculum predicted future performance levels:

a probable Credit/good General in English
a good General in Science
a probable General in Home Economics
probable Foundations in Modern Languages, History and Music

Table 5 (ii): major Maths difficulties, and more modest discrepancies with other subject areas

Pupil No. 3

Comments on Maths performance:

- No Award or a Foundation in Maths - has considerable difficulty
- birth problems led to memory problems - school phobia in primary - tremendous lack of confidence and FEAR of Maths - now gaining confidence though still working at very low level. Reads fluently but sometimes finds hard to follow instructions on the card. Happy to ask. No conception of time. No tables. Working very hard

Cross-curriculum predicted future performance levels:

a probable Credit/good General in Art
probable Generals in Modern Languages, PE and Music
borderline General/Foundation in English History
probable Foundations in Science, Geography and Home Economics

Pupil No. 4

Comments on Maths performance:

- No Award or a Foundation in Maths - has considerable difficulty
- low ability - possibly poor health - gets easily muddled, poor memory and poor basic number skills

Cross-curriculum predicted future performance levels:

probable Generals in Science, History, Home Economics, Computer Education and Business Studies
probable Foundations in English, Modern Languages and Geography

Pupil 5

Comments on Maths performance:

- definite Foundation, possibly No Award, in Maths - sometimes considerable difficulties
- number appears a particular weakness - in class, where the method remains the same throughout an exercise, she has no problem - in tests where the method changes from one question to the next, she has terrible difficulties

Cross-curriculum predicted future performance levels:

a definite Credit in Art
a good General in English
probable Generals in Modern Languages, Geography and Physics
borderline General/Foundation in Home Economics
probable Foundations in Science and History
No Award or a Foundation in Religious Education

Table 5 (iii): moderate Maths difficulties, and major discrepancies with other subject areas

Pupil No. 6

Comments on Maths performance:

- probable Foundation in Maths - has some difficulty
- disorganised learning style, lacks confidence and self-esteem, lack of concentration

Cross-curriculum predicted future performance levels:

a probable Credit/good General in English, Geography and Music
probable Generals in Science, History, Home Economics and PE
probable Foundations in Modern Languages and Art

Pupil No. 7

Comments on Maths performance:

probable Foundation in Maths - has some difficulties

- copes well with booklets and revision exercises but seemed to forget/fail to recognise the process required for individual questions in the test

Cross-curriculum predicted future performance levels:

a probable Credit/good General in English and Technical
a probable General in History
a probable Foundation in Science

Pupil No. 8

Comments on Maths performance:

- probable Foundation in Maths - has some difficulties
- needs more examples on each topic than the others in order to grasp a concept - finally seems to understand but retention of this information is poor. Needs regular revision - tries very hard

Cross-curriculum predicted future performance levels:

probable Credit/good Generals in English and Modern Languages
probable Generals in Science, History and Religious Education
borderline General/Foundation in Geography
probable Foundations in Home Economics, Art, Music and PE

Pupil No. 9

Comments on Maths performance:

- a probable Foundation in Maths - has some difficulty
- basic number work is poor - slow with addition and subtraction (even as basic as 10-3). Has learned tables fairly well, but this can always be done without understanding - disruption in Primary school i.e. moved around and lost touch with what was expected of her - may improve with more work on basic number ... possibly!

Cross-curriculum predicted future performance levels:

a probable Credit/good General in Science, Modern Languages, Geography and Computer Education
probable Generals in English, Technical, Home Economics and Business Studies
a probable Foundation in History

Pupil No. 10

Comments on Maths performance:

probable Foundation Maths - has some difficulty

- reluctant attitude and lazy

Cross-curriculum predicted future performance levels:

a definite Credit in English
probable Credit/good Generals in Science and Business Studies
probable Generals in Modern Languages, History, Geography, Home Economics and Computer Education

Table 5 (iv): moderate Maths difficulties, and more modest discrepancies with other subject areas

Pupil No. 11

Comments on Maths performance:

- probable Foundation in Maths - has some difficulties
- very slow to grasp new concepts - basic skills are not too bad but has terrible difficulty working out what a problem is asking her to do

Cross-curriculum predicted future performance levels:

probable Credit/good General in Music
a good General in Modern Studies/History
probable Generals in English, Modern languages, Home Economics, Technical and PE
probable Foundations in Science, Geography and Art

Pupil No. 12

Comments on Maths performance:

- probable Foundation in Maths - has some difficulty
- short concentration span and poor memory

Cross-curriculum predicted future performance levels:

a good General in English
probable Generals in Science, History and Geography
probable Foundation in Modern Languages

Table 5 (v): average Maths performance, but significantly lower than in other subject areas

Pupil No. 13

Comments on Maths performance:

- a probable General in Maths - an average pupil
- cannot remember tables and will admit this - seems to remember over short term. Tries hard

Cross-curriculum predicted future performance levels:

definite Credits in Modern Studies, History and Religious Education
a probable Credit/good General in English, Modern Languages and Home Economics
probable General in Science
borderline General/Foundation in Geography

Pupil No. 14

Comments on Maths performance:

- a probable General in Maths - an average pupil
- number work poor - tries hard

Cross-curriculum predicted future performance levels:

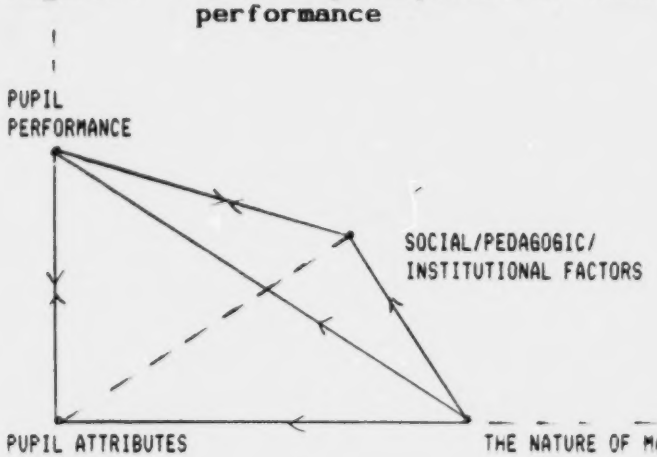
definite Credits in Modern Languages and Religious Education
probable Credit/good Generals in English, Modern Studies and History
a good General in Science
a probable General in Home Economics
borderline General/Foundation in Geography

7.2.3 Discussion of specific Maths difficulties data

Table 4 showed that many teachers accept that there may be learners whose difficulties represent a mathematical parallel of dyslexic-type difficulties. Their perceptions suggested a further parallel: that mathematical difficulties, like those with language, defy simplistic groupings and consequent explanation. The survey of cross-curricular performance certainly confirmed the existence of such pupils; and similarly, scrutiny of the data in Table 5 revealed no obvious patterns common to all the pupils.

As with the reflections upon the full sample, the data for this sub-group conveys a strong impression of pupil-deficit. To some extent, an implied pupil-deficit is an inevitable function of the data gathering: whatever preceding interactions may have contributed to the difficulties, it is in pupil performance that they are manifested, thereby biassing the impression conveyed. Even bearing this in mind, however, a strong sense emerges from the Table 5 data that the major locus of difficulty is perceived to lie within the pupils' inherent attributes. The data suggests that a right-angled triangular pyramid might best represent teacher perceptions of difficulties (See Figure 1). Pupil attributes are at the origin, strongly influenced by the peculiar nature of Maths and the demands it makes. These attributes, in interaction with the demands made by the nature of Maths, have the most important influence upon pupil performance. While other factors may interact and contribute, there is a strong sense that they are less important.

Figure 1 Teacher perceptions of factors influencing Maths performance



Performance descriptions for pupils with difficulties specific to Maths (Table 5) show that lack of conceptual grasp and memory deficits are the most mentioned features, more frequent than number-based difficulties, problems with transfer/application of skills, or personal/attitudinal difficulties. These are pupils of proven relative competence elsewhere in the curriculum - yet in Maths, the abiding sense is that there is something about mathematical thought that they just cannot grasp - and if they do, their grip is so tenuous that it is swiftly lost.

In conclusion, it can be seen that teachers' more general expectations and perceptions of specific difficulties with Maths overlap with those gathered about pupils identified from the cross-curriculum data as having such difficulties. They combine to suggest:

(i) that there are difficulties specific to Maths;

(ii) that they stem from varied sources, and defy neat grouping or explanation;

(iii) but that, as with dyslexic-type difficulties, they derive primarily from inherent pupil attributes in interaction with the distinctive nature of the task in hand.

7.3 Specific Maths difficulties as a function of reading difficulties

Part of the main interview sought to explore the links between specific difficulties with Maths and those with language. Teachers were asked if they had been aware in the past of teaching pupils with dyslexic-type difficulties, and if so, how had these difficulties affected their Maths performance. As can be seen from Table 6, responses were equally distributed.

TABLE 6: Teachers with experience of teaching Maths to pupils identified as having dyslexic-type difficulties.

N = 82

	NO RESPONSE	NO EXPERIENCE	EXPERIENCE
Number of teachers	18	32	32

Predictably, language-based factors dominated comments upon how such difficulties affect Maths performance. Many teachers spoke of such pupils miscopying numbers, and switching their order; of misunderstanding questions; of reading difficulties that hindered comprehension both of instructions and question content. Language difficulties were seen as a barrier that came between the pupil and the Maths at every stage: in accessing the material, in comprehending what was required, in carrying it out, and in presenting and communicating the results of the work. Organisational difficulties, and difficulties with tidiness, layout and spelling remain as hurdles even when the task has been successfully accessed. Teachers spoke too of the extra time needed, of poor memory, and of the negative effect on the pupil's self esteem of these language difficulties.

Despite all of this, some teachers remained relatively optimistic, speaking of above average performance once questions were explained; of compensatory strengths in other areas of Maths; of committed pupils keeping up well by working at home; of the sound understanding that lay beneath the surface difficulties; and of the way in which many of these difficulties could be reduced by appropriate extra help, allowing enough time, and sympathetic teaching.

Others were markedly less optimistic. They spoke of a generally poor performance; of serious difficulties with memory and sequencing; of the significant detrimental effect on Maths of the dyslexic's organisational and logical difficulties; of serious confusion with mathematical symbols, and a reluctance to write that is easily misinterpreted by teachers. They emphasised the clumsiness and poor organisational skills of the dyslexic, and saw the child's reduced rate of work as a serious hindrance. Lastly, they felt that the child's self confidence, both intellectual and social, tended to be badly damaged.

This mixed distribution of experience perhaps reflects to some extent the varying degrees of severity of the problems of the pupils encountered by each teacher: 'dyslexic' remains a very loosely applied term. It reflects also, however, the findings of

studies such as Joffe's (1980), where although most dyslexic pupils were adversely affected in Maths in a variety of ways, a small proportion excelled, mainly through (Joffe suggests) energetic and intelligent use of alternative compensatory strategies.

The cross-curriculum data (Section 7.2.2 above) and the general data from previous sections does not conflict with any of this. There are many occasions where language/reading difficulties contribute to and perhaps cause Maths difficulties; there are those where Maths performance transcends these difficulties; and there are those, well represented in this sample (Table 5), where Maths difficulties can exist among language users of proven competence. While there is much overlap, there is too some clear separation.

7.4 Provision for pupils with specific Maths difficulties

7.4.1 Summary of results

A questionaire was used to ascertain the nature of provision within each participating school. In it, the promoted member of staff responsible for S1/S2 Maths provision described and reflected upon the courses, methods, organisation and materials used in that school. The results are summarised in tables 7 to 9 below.

TABLE 7 Type of provision

N = 16

Category of provision	Number of schools
Wholly individualised schemes	5
Mixed methods, with significant individualisation	5
Primarily class taught, from texts or prepared materials	6

TABLE 8 Class organisation

N = 16

Type of provision	Class organisation	
	Mixed ability throughout	Mixed ability in S1, with some streaming/ setting in S2
Wholly individualised	5	0
Mixed methods, with significant individualisation	4	1
Primarily class taught	4	2

TABLE 9 Role of Learning Support

N = 16

Support	Number of schools
Little or none	1
Consultation	1
Preparation of materials	2
Extraction only	0
In-class support and extraction	2
Limited in-class support	5
Extended in-class support	5

Notes:

1. Pupil focus: most schools targeted support staff towards specified pupils with difficulties while still using them quite extensively with other pupils. Three schools specified that support was for identified pupils only.

2. Year group focus: most schools used support staff in both S1 and S2, but with greater emphasis on S1.

3. Whole school policies for pupils with learning difficulties: all but one Maths department knew of a whole school policy for their school, and felt that their provision met its demands in a positive way.

Among these promoted teachers, individualised schemes were seen as having many strengths. Many departments stressed that they

allowed for individual differences, different starting points, different pace, and differing levels of mathematical aptitude. They were seen as allowing continuity of pupil experience, even where there might be extended absence from school. With frequent in-built diagnostic testing, they allow identification of strengths and weaknesses, and consequent remediation. Independent, self-organised work is encouraged; tasks are short and varied, and often enjoyed; and the less-skilled may enjoy success without invidious comparison invited by materials too evidently different from those of their peers.

Significant weaknesses and drawbacks of individualised schemes were discussed. Most importantly, they were seen as taking considerable teacher time to organise and administer, at the direct expense of time spent in teaching and in explanation and assistance to pupils. The scope they allow for pupils to 'coast' concerned teachers - it is relatively difficult to keep each pupil working at potential, and it would be naive to expect intrinsic interest to sustain a high level of involvement from all pupils. Further, some felt that such schemes do not make the most effective use of teachers' skills and potential contributions to learning; and, at a more prosaic level, they are expensive and easily damaged and worn.

Those supporting whole-class teaching from texts or prepared materials felt that it ensured adequate and uniform coverage; that it allowed pupils to be pressed, with scope for extending the more competent; and that it offered pupils a secure, predictable and familiar context for learning.

Set against that, it was acknowledged as sometimes inflexible, over-demanding, and insensitive to the very wide range of skills and competencies to be found within a class. For some pupils, too much ground will be covered, and there is a methodological mismatch with pupils' earlier experience in primary.

Whatever the provsion, many schools listed among their desired improvements more help from learning support, smaller classes to allow more time per child, and more extensive resources and materials. Among those using individualised courses, there was a

sense that a certain amount of extraction and small group teaching would be helpful; while those using whole-class teaching were more likely to look to setting or streaming as of potential benefit.

7.4.2 Discussion of provision

The original research question asked whether provision reflected the needs implied by teachers' perceptions of specific difficulties with Maths. It has been shown that teachers do feel that these difficulties exist, that otherwise able pupils may be encountering difficulties in Maths. It seems that teachers see these difficulties as deriving mainly from the demands made by the peculiar nature of Maths in interaction with the particular attributes of the pupil in difficulty: Maths is seen as linear, abstract, uncompromising and demanding - success with it demands the ability to grasp abstract concepts, retain them, understand them enough to apply them, and a learning style that can accept continuing challenge and some experience of failure. There are few plateaus in Maths: unlike many other subjects, there are few points at which further progress involves little more than refining, deploying and extending a finite repertoire of skills already gained. In Maths perhaps more than in other subjects, success leads inexorably to consequent further challenge. One Principal Teacher of Maths crystallised this most succinctly: "ALL pupils SHOULD experience difficulty - this is inherent in the acquisition of abstract concepts - and those who never experience difficulty are not being presented with the challenge necessary for the development of skills or concepts."

For these pupils, then provision and delivery must be enormously sensitive to the many ways in which learning may falter, and be able to adjust both pace and gradient in any area. It must actively seek to present difficulties if learning is to occur, but at a level that suits each learner.

For the pupils being considered, individualised schemes, despite their disadvantages, seem to come closest to this, with their inherent flexibility of delivery and with the reduced threat to

self-esteem that they pose. While they may be inappropriate for the language-disabled learner, and perhaps for some others, for this population of competent readers who none-the-less fail in Maths, they come closer to adequacy than their contenders. It is difficult to see that whole-class teaching in any form could help these pupils.

But still, individualised schemes cannot meet fully the needs of pupils with difficulties specific to Maths - not if the difficulties are as various and stubborn as teachers' descriptions suggest. Most who favour individualised schemes spoke too of the need to develop further materials and resources. If the needs of pupils with specific Maths difficulties are to be met within the normal classroom, such development would have to be considerable.

The pupil with difficulties specific to Maths may falter in any of so many topics or areas of learning: shape, logical reasoning, understanding of number, grasp of a certain idea, retention, transfer and application ..... The project data suggests that often the pupil will cope adequately in some areas, while encountering significant delay or failure in others. While individualised schemes go a long way towards sensitive provision, they remain essentially uniformly paced: there is little structural accommodation for extended work at one level, in one area, if or when such a need arises for a pupil with a specific difficulty. Individualised schemes seem premised upon an assumption that a certain level of exposure to a certain topic shouls allow it to be mastered.

Even where there is structured allowance for topics to be treated at different rates and levels, and with consolidation materials available (for example, the 'L' levels and the Extra Practice booklets of the KMP materials), no scheme seems to envisage and allow for the kind of decisive 'ceiling effect' that distinguishes the performance of many pupils with Maths difficulties, that near-total halt encountered by a pupil in one area or another. That is, none allow for a pupil to stay with a certain topic for a most considerable length of time, re-approaching it again and again from different angles, allowing

most extensive consolidation and frequent return for rehearsal and revision. Nothing less would meet the needs of these pupils. But given that such ceilings may be encountered to varying extents in any topic at any level, it is little surprise that so comprehensive a scheme does not exist.

In principal, individualised learning should be able to meet the needs of pupils with specific difficulties in Maths. But it seems likely that in practice they do not - tailored support, either through extraction or within the normal classroom, seems essential, and such time-consuming ad hoc provision makes demands upon resources that often cannot be met. Further, the varied nature of the difficulties manifested by these pupils tends to preclude the use of streamed groups as the most appropriate provision, even quite small groups: even with such a group, the needs might remain too various to be met effectively by class/group teaching.

For these pupils, and in the absence of more generous staffing specifically for that purpose, individualised learning using using materials and resources far more extensive than those currently available seems to be indicated. As can be seen from Table 7, the majority of schools do make use of the kind of scheme that has, if expanded and developed, at least the potential to meet these needs. But it seems possible that the task of rendering such a classroom scheme extensive enough, flexible enough, and comprehensive enough to meet this potential is unrealistic. In the same way that it is now accepted that the problems of the dyslexic pupil cannot be met wholly within the context of the normal curriculum, so it is probable that difficulties specific to Maths require a level of attention that is not usually currently available.

8. Conclusions

The project sought to explore the existence and nature of difficulties specific to Maths, and to consider the extent to which provision reflected adequately the learning needs thus exposed. The chosen means of exploration was to gather the

reflective impressions and subjectivities, the professional understandings and perceptions, of teachers involved in delivering the Maths curriculum.

The resulting data contains patterns of sufficient clarity to allow answers of some confidence to the questions posed:

(i) Teachers' experiences and understandings do suggest quite clearly that pupils who are otherwise competent may experience significant difficulty in aspects of Maths;

and (ii) that the needs stemming from these difficulties can be met only in part by the types of provision and delivery currently in common usage.

The research questions operationalised into a number of more focused strands of investigation.

First, teachers were interviewed to explore in some detail how they perceived and understood mathematical difficulties. The resulting picture suggested that, while teachers recognised the unnecessary pitfalls and hindrances caused by social, pedagogical and institutional factors, the main difficulties arise from the ways in which some fairly fixed attributes of the learners (e.g. their memory, certain personality traits, their ability to relate the abstract to the actual) interact with demands that stem from the intrinsic nature of Maths (e.g. its abstraction, its linearity). From this wide range of experienced practitioners there was a clear sense that, for most pupils experiencing significant long-term difficulty in part or all of their Maths, their level of performance probably offered a fair reflection of their level of potential.

Secondly, teachers' understandings of difficulties specific to Maths were explored. It emerged quite clearly that relatively few were sceptical of their existence, attributing them to a range of factors centred about the pupil, again fairly fixed factors stemming from the interaction between the nature of Maths and the attributes of the particular pupil. Most conspicuously, many teachers emphasised the distinction between difficulties with Mathematics and those with Arithmetic: number-based difficulties,

dysfunctions with calculation and with the very understanding of number, were seen as separate from difficulties with other areas of Maths, and often more severe and more widespread. (This discussion has not found it possible to provide a precise definition that distinguishes comprehensively between Arithmetic and Mathematics - but evidently there are distinctions that are clear enough in teachers' minds to see difficulties in the two areas as separate phenomena).

The profiles of identified pupils confirmed the existence of these difficulties specific to Maths, suggesting not a unitary phenomenom, but the kind of variable, multi-factor syndrome that we expect with dyslexic learners. Performance patterns and descriptions confirmed that while different kinds of difficulties may often overlap and interpenetrate, they may too exist independently: for example, pupils may have specific difficulties in language alone, in language and Maths, or in Maths alone. While the project did not seek to quantify incidence, the data gave the impression of a relatively low level of incidence.

Throughout, there was a pervasive sense that these difficulties relate to pupil attributes that are relatively fixed - as with dyslexia, there was a sense that specific difficulties with Maths tend to be relatively intransigent and inherent features of the pupil's profile as a learner of Maths. They might be lessened, or coped with - but probably they will not be eradicated.

Given the picture that emerged, it is not easy to be optimistic that provision currently available in schools can maximise the mathematical potential of these pupils. There was a strong sense that individualised schemes had been developed quite rigorously and effectively, as the only means of curriculum delivery that might hold out hope - but that even at their best, it would be hard for them to provide adequately for pupils with specific difficulties in Maths.

In the absence of schemes considerably more extensive, developed and flexible than any currently available, ad hoc and time-consuming provision, individually tailored to the needs of each pupil in difficulty, be it in class or by extraction, would

appear to be the only effective provision. Given current resourcing levels, that seems unlikely in the forseeable future.

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Specific Learning Difficulties in Mathematics

Appendix 1: a review of the literature

1 Sources of difficulty with Maths

Difficulties with Maths are not rare. Sometimes they are spoken of with a kind of perverse pride.

They can stem from a number of factors, separately or together: social and educational factors, the individual's cognitive performance, neurological make-up, personality and learning style, all interacting with each other and with factors intrinsic to the nature of the subject.

In the same way that, depending upon definitions, explanations of dyslexia tend to draw upon a neurological aetiology, so must a dyscalculic explanation of difficulties specific to Maths depend upon the exclusion of contending explanations, and rely upon congenital inheritance. As will be seen, the contending explanations are many and convincing.

Mathematics tends to be defined as the science of quantity and quantitative relations. By means of numbers and other symbols, it considers both spatial and numerical relationships (Sharma and Loveless 1986).

Webster's Dictionary includes the entry (perhaps significant when considering why people might find it so hard): 'Mathematical: ....rigorously exact, perfectly accurate ..... being beyond doubt or question'.

Its rigour combines with its abstraction. Maths is inherently abstract. The processes of abstracting and classifying are central to it (Skemp 1971), and the very essence of Maths is that it abstracts to a stage beyond words. Mathematical thinking exists as a distinctive entity partly because it explores areas of thought beyond the easy control of words. It has developed and

makes use of a whole different symbol system to express ideas and relationships in a very compressed and precise way. They are ideas and relationships that cannot easily be put into words.

The purpose and essence of Maths is to solve problems (Orton 1987). It demands the acquisition, organisation and access to knowledge, rules, techniques, skills and concepts with the aim of providing solutions to novel situations. It is both an organised body of knowledge and a creative activity. For some learners this may imply an internal tension (Orton 1987): creativity involves independence, judgement and a readiness to take risks. School Maths, with its apparent logical certainties, pays little attention to these features (Polya 1957, Lansdown 1978, Plunkett 1979, Giles 1981, Orton 1987).

'Algorithms' play an essential and central part in this. These are the formal routines that we learn and depend on so much, the 'rules, techniques andd skills'. They are the mathematician's tools, his way of compressing, and providing a short cut.

As will be seen, they are essential to success in Maths, but probably contribute more than anything else to confusion and lack of understanding. Too often, the algorithm tends to take central place, a tool wielded by someone with little understanding of its function. The underlying meanings are left behind: "the smaller number goes on the bottom line"; or, in later years, "turn it upside down and multiply". In Ausubel's terms (1968), learning has become rote. It is not meaningful, and the learner's mind quickly becomes a cluttered mess of confusing rules.

It is helpful in other ways to see mathematical thinking as having two main strands. Crudely, these might be summarised as the distinction between skill and knowledge, between procedures and concepts (Polya 1957, Floyd 1981, Hiebart 1986). Hiebart and Lefevre (Hiebart 1986) think of maths in terms of 'procedural knowledge', dominated by rules and algorithms, and 'conceptual knowledge', a connected web of knowledge, where the links themselves are as important as the pieces of information they link together.

The question of which of these two kinds of knowledge is most important, and what should be the appropriate balance between them, lies at the heart of most debates about Maths teaching.

2. 'Mathematical ability' - does it exist?

In Maths perhaps more than in other subjects there is a feeling that you need to be born with the right *kind* of intelligence, 'and plenty of it' (Giles 1981).

Cluster analysis, however, suggests that Maths ability is not a single ability, but a cluster of several. That they are gathered together under the purely convenience heading 'school maths' is an arbitrary function of school organisation (Joffe 1980).

Often, the skills needed in Maths are seen as forming two main groups. For example, verbal abilities may be contrasted with visual abilities (Bartlett 1932), or spatial with linear (Joffe 1980). For Joffe, spatial skills are needed in understanding shape, symmetry, and relative size and quantity, while linear skills contribute to understanding the kind of sequential and ordered symbols and representations found in the number system and algebra.

Recent factor-analytic studies have yielded separate factors for mathematical inference and mathematical knowledge independent of general intelligence or verbal skills, suggesting that mathematical ability is, statistically at least, an independent cognitive entity (Spiers 1987).

Spiers goes on to consider a question important to a neurological perspective of Mathematical ability: whether calculation is a higher cortical 'function' that can be localised within the cortex, and if so, where; or whether it is better seen as a 'performance', a secondary process based upon other more fundamental functions? He suggests that in the sense that we regard language as a higher cortical function, so should we define calculation.

3. Difficulties with Maths

3.1 Social/institutional factors

It is a frequently recurring theme that Maths failure is school induced (e.g. Ginsburg 1977, Plunkett 1979, Giles 1981, Dickson 1984, Liebeck 1984, Larcombe 1985).

Certainly success levels in Maths are generally very low. If teachers test a skill taught and practised some time ago, probably they do not expect a generally high level of competence. Given our recognition of the rigorously linear nature Maths, we teach with a remarkably high tolerance of failure, often even an expectation of failure.

With failure built in in this way, perhaps it is not surprising that Maths is associated with varying degrees of boredom, dislike, anxiety, alarm, fear and other emotions that accompany expectation of failure (Giles 1981, Allardyce and Ginsburg 1983, Orton 1987).

These are institutional features. They stem from trying to convey a great deal of highly abstract content in a relatively short space of time. These are the factors that cause us to rely so much on the short cuts provided by formal algorithms.

It may be that much failure is due to learning tricks in place of conceptual understanding. Children sometimes seem to think of mathematics as an isolated game with peculiar sets of rules and no evident relation to reality (Ginsburg 1977).

Many writers (e.g. Ginsburg 1977, Plunkett 1979, Giles 1981, Allardyce and Ginsburg 1983, Dickson 1984, Liebeck 1984) suggest that standard algorithms are short cut devices introduced before the child has any real grasp of what is involved. As such, they conceal the underlying logic, specially from the less able. Any initial glimpses of reason will be lost through this process of mechanising. Seen this way, schools are suppressing an intuitive mathematical ability, rather than building on it.

4. Difficulties inherent to the idividual

These may arise from neurological, cognitive or affective factors, separately or in combination.

4.1 Language-based difficulties

These have received a lot of attention from researchers (e.g. Floyd 1981, Cockcroft 1982, Harvey et al 1982, Dickson 1984, Shuard and Rothery 1984). Quite apart from any other reading difficulties, the extensive and significant, but often subtle, differences between Mathematical English (ME) and Ordinary English (OE) have been identified as the source of considerable difficulties. They have been well explored, and need not be documented in detail here.

4.2 Personality factors and Maths difficulties

Probably there are aspects of Maths that appeal to one individual while repelling another, functions perhaps of preferred styles of study and personality. The affective and the cognitive interpenetrate.

It has been seen that skills and abilities are not evenly or uniformly distributed. Within one individual, certain clusters of skills may dominate, and this can sometimes be seen in terms of distinctive learning styles (e.g. Pask 1976, Chinn 1992), applicable to Maths as well as other areas: for example, those who prefer to build their understanding step by step contrasted by those who prefer a more holistic approach.

Certainly, school Maths tend to be a socially-isolated activity, and one that does not demand the revealing of emotions in the way that other subjects may. Further, it is an area of certainties, with all the sense of beauty and completeness this can bring to some. It is often viewed as highly competitive, satisfying to some and unpleasant for others. Similarly, some like the fact that answers are 'right' or 'wrong'; while those

who thrive on discussion and debate would not find this aspect pleasing.

It seems helpful to see a personality continuum relevant to Maths success or failure, ranging from the very impulsive, through the reflective, to the ultra-reflective (Orton 1987).

On the left, the impulsive learner is too ready to take risks, and will not be consistently successful. In the middle, the reflective learner is prepared to take limited risks, and is more likely to be successful. On the right is the far too cautious learner, terrified of failure and unable to take any risk. These pupils will not be successful.

The 'right/wrong' nature of most responses to maths makes it easy to damage the self esteem of the learner, and many writers suggest that this happens again and again, to too many of us (e.g. Allardyce and Ginsburg 1983, Dickson 1984, Orton 1987)

4.3 A hemispheric perspective

The hemispheric construction of the brain receives a lot of attention (Krutetskii 1976, Wheatley 1977, Sharma 1979, DeLoche and Seron 1987).

Sharma identifies two types of Maths learners: the Quantitative vs. the Qualitative maths learning personality (Sharma and Loveless 1986, Chinn 1992). Those with a left hemispheric orientation are good in language, verbal expression, problem solving bit by bit, quantifying, quantitative operations, and anything that builds up sequentially, such as counting, addition, multiplication. When given a word problem, they look for a familiar algorithm. Those with a right hemispheric orientation look at problems wholistically and explore global solutions. They are good at identifying patterns, both spatial and symbolic. They are creative and faster at solving 'real-life' problems.

As well difficulties that might arise from uneven hemispheric performance of this kind, there may be a problem in moving

information from one hemisphere to other during processing. Further, there may be a problem in overall control by the left hemisphere (Sharma and Loveless 1986).

4.4 Neurological explanations: dyscalculia

There is ongoing interest in neurological explanations of learning difficulties (e.g. Kosc 1974, Krutetskii 1976, Farnham-Diggory 1978, Sharma 1979, Joffe 1980, Orton 1987).

Gonzalez and Kolers (1987) distinguish between the cognitive and neurological approach by suggesting that while the neuro-psychologist is most interested in associating particular impairments with particular lesions, the cognitive psychologist is concerned with the mental operations that underlie particular performance. As the debate between 'function' and 'performance' implies, however, the two disciplines interpenetrate.

There are many ways a learner can encounter difficulties that can not be attributed to his or her school experiences. While they may be seen as cognitive, they imply a congenital, neurological origin. They include (Bley and Thornton 1981) visual and auditory perception problems, spatial and temporal disabilities, or motor deficits. There may be memory deficits, in working memory or long term. Visual deficits may make copying difficult, while auditory deficits lessen the ability to learn from oral drills. When dealing with word problems, memory deficitsimpede easy retention of items in order to operate on them, specially for longer problems. There may be sequencing deficits - much Maths involves sequencing; or there may be integrative deficits, a difficulty in pulling information together. In all of these, the cognitive/neurological borderlines are not clear, and probably not important.

The principles used to define dyscalculia are similar to those used to define dyslexia: developmental dyscalculia is a special difficulty with numbers not due to poor teaching or low IQ. (Kosc 1974, Allardyce and Ginsburg 1983, Sharma 1986). A neurological cause is implicated.

Developmental dyscalculia is neurologically defined as a disorder of the maturation of mathematical abilities which has its origin in a congenital or genetic disorder in a specific area of the brain (Kosc 1974). When there is a pronounced inability for mathematics, a low level of functional maturity of the inferior parietal region of the cortex and its connections with other sections of the brain is observed (Krutetskii 1976, Sharma 1986).

Studies of acquired and developmental dyslexia have have provided each other with valuable data and insights, while illuminating too the normal functioning of the unimpaired user of language. There has been less interpenetration in the area of mathematical cognition (DeLoche and Seron 1987), and apart from Kosc's work (1974), the neuropsychological studies that have taken place provide much of the sparse empirical evidence available in this field.

5. Links between language difficulties and mathematical difficulties

While, there is no clear evidence yet that arithmetic processing can be functionally localised (Spiers 1987), calculation can best be conceptualised in terms of a network of several component processes, each perhaps with a distinct localisation in a certain site, and mediated at different levels within the nervous system. Such a 'network model' allows explanation of why language and calculation deficits sometimes overlap and coexist, while in other cases clear dissociations are established (Spiers 1987)

Often a pupil identified as dyslexic will manifest maths problems: the descriptive signs of dyslexia include such things as an inability to subtract, unless with concrete aids, and difficulty with tables (Joffe 1980). Mycklebust and Johnson (1962) placed dyscalculia in sixth place on their list of common features found among their sample of 200 dyslexics.

Joffe's study of dyslexics' Maths performance (1980) suggested that 60% of the dyslexic sample were retarded in arithmetic to some extent, the problem being severe for 50%. However, 10%

excelled in all aspects of school maths, apparently by adopting alternative strategies to cope with numbers and problems. She found that calculation tended to be the major area of weakness, particularly multiplication and division, and attributed this to the dyslexic's characteristic difficulty with verbal labelling and using short term memory. Spatial aspects and concept understanding she found to be usually unimpaired.

Joffe points up a range of extrinsic factors that might exacerbate the maths difficulties of a dyslexic: apart from the obvious need for reading skill, considerable emphasis may have been put on improving language skills, at expense of other skills; or to avoid putting extra stress on the dyslexic learner, maths may not have been emphasised.

6. Incidence of specific difficulties in mathematics or arithmetic

The data is sparse, and sometimes ill-defined. While referring often to 'mathematics', it tends to focus upon difficulties in arithmetic and calculation.

Acknowledging that most Maths difficulties arise from other factors, Kosc's influential Bratislavia study (1974) suggests that more than 6 % of normal 11 year olds show signs of developmental dyscalculia.

Kosc's study does not, however, supply data upon the reading abilities of the pupils concerned. Rourke and his colleagues (1978, 1978, 1983) considered pupils with arithmetic problems, reading problems, and arithmetic-and-reading problems, and suggested that arithmetic disorders fall into two categories: specific arithmetic disabilities where pupils showed visuo-spatial and tactile-perceptual skills relatively poorer than their verbal skills; and arithmetic-and-reading disabilities, where non-verbal skills were better than verbal skills. However, their population of children referred for learning difficulties gave no indication of incidence in the general population.

Epidemiological data is available from a New Zealand study reported by Share et al (1988), suggesting that while 6.4% of children show an arithmetic-and-reading disabity, 4.8% have a specific arithmetic disabity.

A recent study by Lewis, Hitch and Walker (unpublished at time of printing) used a population of over a thousand 9-10 year olds to explore the incidence of arithmetic disability within the general population in UK. Their rigorously defined criteria of pupil performance indicated that 3.9% of their sample had a reading-only disability, 2.3% an arithmetic-and-reading disability, and 1.3% were disabled in arithmetic only.

Such results suggest that while some arithmetic under-achievement might stem from deficits in verbal processing, there are a small number of children with low scores on the arithmetic test and normal range scores on reading test, whose arithmetic difficulties can be attributed to a general deficit in language-related processing.

7. Implications for this project

Clearly, a review of the literature, while indicating that there may be a number of learners whose difficulties tend to cluster around arithmetical or mathematical activities, does not reveal any significant evidence that could confirm dyscalculia as a specific, separable neurological condition.

Fear of failure, poor educational practice, and preferred learning styles that are inappropriate to the distinctive nature of mathematical thought, all remain as contending explanations of school failure specific to mathematics.

This project, in tapping the understandings and perceptions of those involved in teaching Maths, can neither confirm finally nor refute the condition nor its aetiology. Hopefully, it does extend and develop our understandings of how it is manifested in that most central location, the ordinary classroom.

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Appendix 2: Some methodological considerations, and evaluation

1. The project as it was intended

1.1 The origins of this project were opportunistic, in that an individual teacher with some experience and interest in educational research negotiated a research opportunity with a University Education Department and a Regional Education Authority. The research was undertaken on the basis of release (largely unreplaced) for one day a week over 18 months.

1.2 The context was a government-sponsored project concerning policies, practice and provision for pupils with specific learning difficulties. The hope was to enhance the main project through developing a significant extra dimension, while at the same time involving other classroom teachers (not seconded) as widely as possible, thereby providing them with the staff development benefits to be gained from immediate experience of a major research project.

It was hoped to keep the Regional contribution separate enough for separate evaluation, both in research terms and in terms of its staff development value to the Region. The particular circumstances suggested an exploration of specific difficulties in Mathematics as a potentially useful way to do this.

1.3 The research methods and design had to reconcile two fundamentally conflicting demands: they sought to maximise the involvement of teacher-researchers, allowing for genuinely shared ownership of the research through the opportunity to be involved in the developing and shaping of it; at the same time they sought to

minimise the demands such involvement would make upon teacher time.

The initial design envisaged a sequence of case studies. This would allow for ongoing adaptation, if wanted: each new study could build upon the insights gained from the preceding one, and be adapted to fit the new circumstances.

While the case studies need not be strictly end-on, such an approach would allow a progressive refining of understanding and technique, with each study drawing upon the understandings gained from preceding studies.

This was to offer a framework that permitted some adaptation to suit the interests and circumstances of each school, allowing a share in research design and a subsequent sense of ownership that was felt to be an important potential strand in the involvement of each teacher-researcher.

2. This project in the context of teacher research involvement

2.1 Typically, teacher involvement in research can take several forms.

2.2 Most often, perhaps, the role of teachers has been essentially passive: they are involved simply because of they represent the interface between the providers and the recipients of formal education. Their role has been to cooperate with theoreticians, administrators or policy makers, in such activities as observing, noting, testing, and implementing externally-derived initiatives.

2.3 Often, too, the teacher may be an object of research, rather than a researcher. Sometimes the resulting analyses may be perceived as one-sided and perhaps arrogant (McNamara 1980). They may be seen as unhelpfully

uninformed and perhaps fundamentally flawed: praxis is being investigated by those who are not practitioners. 'Since only the practitioner has access to the commitments and and practical theories which inform praxis, only the practitioner can study praxis.' (Kemmis p. 45, in Keeves 1988).

2.4 However, it seems likely that the increasing professionalisation of the teaching force has brought with it an increase in small scale research activities by individual teachers, often perhaps as part of gaining further formal qualification. Such studies may take any form, and focus upon any aspect of the educational process. Their common feature is that they will be locally generated and implemented, and thereby address issues of concern to the implementer. They will encourage, and often involve, professional reflection and evaluative scrutiny.

2.5 Also perhaps as part of this increasing professionalisation, there has been increased interest in action research, where research is harnessed directly to the solving of a specific problem.

It is a form of research carried out by practitioners into their own practice (Ebbutt, 1985, Kemmis, Stenhouse, et al, in Reeves 1988) . This tends to imply small scale, locally organised, reflective and problem-solving research. It may stem from an internal initiative, or be externally derived but still probably fairly local.

It involves professionals (usually teachers themselves) experimenting with their own practice while seeking simultaneously to improve that practice, understand it, and understand the situation within which it occurs. It involves a spiral, in which a problem is observed and considered; a response is formulated; it is implemented; the results are observed and reflected upon; if the problem remains, the cycle may be repeated.

Seen this way, action research places within a formal framework the professional's instinctive search for improved practice.

2.6 This project draws upon the action research tradition in that it involves teachers in exploring their own practice; but is primarily reflective rather than problem solving. Reflection does not lead directly to intervention.

At its centre is the idea that '... participants' perspectives and categories [shape] educational practices and situations. .... Actors' understandings are crucial in understanding educational action' (Kemmis p.44, in Keeves 1988).

2.7 It draws too upon the case study tradition. The initial design involved a sequence of case studies, and '... the task of the case study is to produce ordered reports of experience which invite judgement and offer evidence to which judgement can appeal.' (Stenhouse p.49, in Keeves 1988).

Stenhouse (in Keeves 1988, Skilbeck 1983) sees four broad categories of case study: ethnographic studies, where a single case is studied in depth using techniques derived from anthropology, such as participant observation and interview; evaluative case studies to provide decision makers with needed evidence; educational case studies, concerned with enriching educational understanding through the 'systematic and reflective documentation of experience'; and action research case studies, where feedback of information guides the revision and refinement of the action.

2.8 Here the hope was to draw upon the actors' understandings within the framework of a fairly wide educational case study. While the way in which the case studies were envisaged had to be adapted to match emerging circumstance, that central purpose remained the same:

through systematic reflection and documentation of participant perspectives, to enrich understanding and to provide evidence to which judgement might appeal.

3. The project as it developed

3.1 Intentions were modified significantly prior to data-gathering. The design that emerged is described in Section 4 of the report.

3.2 The original conception, of a sequence of case studies each adaptable in light of the insights gained from preceding studies, was replaced by a more conventional design, where the same data-gathering instruments were used in each case study.

3.3 This stemmed from two related factors. Firstly, the satisfactory development and piloting of the data-gathering instruments took considerable time and care. Secondly, arrangements for the involvement of classroom teachers as research collaborators took some time to put into place, leaving relatively less time for data-gathering and processing.

3.4 To have retained the original design, with the studies in sequence and each allowing for significant review of the research instruments, would have permitted the involvement of fewer teachers and schools. Accordingly, the same data-gathering instruments formed the common core of all the case studies. This extended considerably the experimental population and the numbers of teachers and schools that could be involved. At the same time it allowed for comparison and pooling of data, forming a single, larger body of research evidence.

4. Implementation

4.1 Initial arrangements with Tayside Region were made through the Directorate, and the Advisers in Learning Support and in Mathematics. After that, the Adviser in Learning Support provided the main channel of communication between the project and the Region, with subsequent involvement from the newly-formed Regional Research and Development Service. (See Appendix 3.)

4.2 In September 1991, the opportunity was advertised by the Directorate to all the Region's secondary Maths and LS teachers. Initial interest was expressed by staff in twenty-one secondary schools.

During late October/early November, a sequence of meetings was held in different parts of the Region (mainly after school), to explain the project in more detail and acquaint staff with the data-gathering instruments.

4.3 This was followed by data-gathering in schools, involved staff interviewing each other and their subject-colleagues, and administering questionaires to their colleagues in other subject departments. Mid-February was agreed as the desired deadline for data gathering, with late May/early June as the target date for report completion.

Staff wishing to be involved in the subsequent processing and analysis indicated this when returning their school's data (see Appendix 4).

4.4 A time-scale that seemed to contract rapidly dictated the nature and extent of this subsequent involvement.

It was deemed vital to derive a content analysis scheme for the main part of the data, the interview responses, that was robust and comprehensive. Accordingly, sample pages from interview responses were despatched to all

involved staff to allow for the simultaneous development of a number of conceptualisations that could then be compared, merged and refined as appropriate.

This proved unrealistic, and instead the seconded researcher's own draft scheme was distributed for comment. After subsequent adaptation, it was used for interview analysis. Again due to time limitations, the interview analysis was carried out by the seconded researcher, rather than shared among involved staff.

4.5 The cross-curricular performance data for pupils with Maths difficulties were collated by the seconded researcher, and the resulting pupil profiles were sent to all involved staff. The resulting combined analyses were used to agree upon identification of pupils with difficulties apparently specific to Maths.

4.6 During these later stages time constraints made it clear that the role of involved staff had been substantially reduced: instead of 'shared ownership' of the project the role had become one of monitoring, advising, supporting and validating.

4.7 Using the data thus gathered and analysed, a first draft of the research report was prepared by the seconded researcher, and passed to both Regional and University staff involved.

4.8 It had been hoped that the project would allow for more detailed exploration of the pupils identified as having difficulties specific to Maths - how to screen for these difficulties, diagnose them and then how to intervene in order to lessen them. A number of involved staff had expressed particular interest in this strand. Time constraints precluded this, however, and it remains to be completed if time and resources can be made available.

5. Evaluation

5.1 Two aspects of the project need evaluating, partly separate though partly inter-penetrating: the project as a staff development opportunity; and the project as a useful and valid research contribution.

5.2 As a staff development opportunity it was successful in that there was an extensive response, often in some depth. It involved large numbers of practicing teachers in interviewing and data-gathering, and in reflecting upon their own values, beliefs and practices, and those of their colleagues. A further, smaller number were involved in considering the research as it developed, in monitoring, analysing and advising.

At the same time it fell well short of an important original intention, in that constraints of time and resources meant that shared ownership was significantly more limited than intended. For the same reasons, it did not prove possible to explore the original design concept, of a sequence of case studies, each building upon and developing out of the insights gained from the preceding studies. Such a design would have conferred very real shared ownership, with an opportunity for sharing fundamental design considerations with the case study team in each participating school.

5.3 In terms of its contribution as a valid piece of research, it proved perhaps more revealing and effective than might have been expected.

Its central idea - that practitioners should access and reflect upon their own corporate professional insights - allowed for a useful and extensive exploration of the difficulties apparently experienced by pupils in Maths.

It is a research technique of some 'ecological validity'. Pupils themselves tend to be the most frequent focus for the educational researcher - they are observed,

interviewed, tested, measured and interpreted in countless different ways.

Teachers, where they come into the picture, tend sometimes to do so only as part of the interactive context within which pupils operate. This is proper enough and quite acceptable.

However, perhaps in seeking to break free from the more traditional and positivistic approaches to exploring the processes of learning, some researchers have tended to present the teacher as an impediment to learning. An impression is sometimes conveyed that it is the fundamental conservatism of teachers more than anything else that limits effective learning, that blocks childrens' access to unrestricted discovery and exploration.

While sometimes it might be so, it has allowed for the development of a sometimes one-sided research culture that further discourages the kind of reflective teaching practice that should be encouraged. As discussed in the main report, the teacher is the only educated participant with continuous and intimate experience both of the delivery of the curriculum and of the response of learners to that curriculum. Given at the same time that teachers, more than anyone else, create the conditions within which learning does or does not occur, such neglect of their professional understandings seems unwise on all counts.

A useful aspect of the research reported in this project is that it points up the potential value of attending to 'the view from within'. The process of practitioners accessing and reflecting upon their own corporate professional insights can yield understandings that are both valid and important, while simultaneously developing the wider professional potential of those practitioners.

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Appendix 3:
Tayside Region personnel involved in the project

Directorate and Advisory Services

Mr. John Christie, Depute Director (Educational Development)
Mrs. Christa Beattie, Adviser in learning Support
Mr. Ian Bryers, Adviser in Mathematics
Mr. Hugh MacRae, Research and Development Service

Involvement in data gathering and subsequent support and monitoring of the project:

Denise Chaplain, St. John's High School
Anne Crook, Perth High School
Margaret Dewar, Arbroath Academy
Meg Dixon, Rockwell High School
Dennis Gillespie, Perth Academy
Maureen McElroy, Auchterarder High School
Margaret McLintock, Monifieth High School
Judith Moore, Pitlochry High School
Isobel Roxburgh, Perth High School
Sheena Welsh, Arbroath Academy

Involvement in data gathering - the Maths and LS staff of:

Alyth High School
Arbroath Academy
Arbroath High School
Auchterarder High School
Blairgowrie High School
Brechin High School
Harris Academy
Kinross High School
Monifieth High School
Perth Academy
Perth High School
Perth Grammar School
Pitlochry High School
Rockwell High School
St. Columbas High School
St. John's High School

Thanks also to the staff of several other schools who expressed interest but whose other commitments precluded further involvement.

Learning Difficulties in Mathematics

(Material in bracketed italics is headings, or for the guidance of interviewers. It should not be spoken during the interviews.)

(Introduction:)

The school is taking part in a Scottish Office research project with Stirling University.

The project is looking at 'specific learning difficulties' - that means difficulties like dyslexia, where people have serious and unexplained problems in just one part of their abilities.

There has been a lot of research done into language-based difficulties of this kind (dyslexic-type difficulties). There are other researchers are looking at how these are dealt with, as part of this project.

But much less is known about similar kinds of difficulties in Maths. There's no certainty about whether they exist, or how severe or widespread they might be.

In this part of the project, we want to gather as much information as we can about how teachers think of Maths difficulties, and to get their thoughts about why certain of their pupils might find Maths hard.

We can then look at how these pupils cope in other subjects, and get some kind of picture of the patterns of strengths and weaknesses they show, comparing their Maths with other areas.

Obviously, your help in answering these questions, and sharing your ideas about some of your own pupils, would be much appreciated.

We will start by talking in a very general way about how you see difficulties in Maths. Then we can move on to consider specific pupils.

The whole conversation will be confidential. No pupils or teachers will be identified in any reports.

Is there anything you'd like to know or ask before we start the discussion?

(Part 1. Maths difficulties in general)

First of all, let's talk about Maths difficulties in general.

(1.1) Some pupils find Maths difficult. It is sometimes seen as a difficult subject.
Why, in your opinion, is it so hard for some pupils?

(leave plenty of time - accept a longish pause, even if it seems awkward)

(1.2) Do you think that some pupils find Maths harder than they find other subjects?
(If so) Can you say why this might be the case?

(Part 2: Particular pupils with difficulties in Maths)

Let's move on now to particular individuals in your classes. Don't forget, although we do need actual names so that we can find out about how these pupils manage with their other subjects, this IS confidential, and they won't be mentioned by name in any report.

(2.1) So, please consider your own S1 and S2 classes. Can you identify and give me the names of four or five pupils in each class who seem to be experiencing significant difficulties? They need not necessarily be the least able, though they may be.

(probably best to limit to two classes)

(2.2) Taking one of them at a time, can you now suggest what might be the reasons for her or his difficulty? Obviously, the more detailed you can make your thoughts on each pupil, the more useful the data will be.

The first one you mentioned was ....., etc

(2.3) You started the interview by thinking in general terms about the reasons for Maths difficulties.
(Recap the main points made by the interviewee in Part 1)
With these in mind, is there anything you'd like to add to your comments on each pupil?

(2.4) For each of these pupils, can you give a rough idea of their present Maths performance compared with other pupils, by grading them on this 1 to 5 scale?

(pass across the guideline)

(2.5) Sometimes teachers are surprised that certain pupils have difficulties. Maybe their appearance, manner, peer relationships, or informal talk, suggest a certain competence.
For each of the pupils you have discussed, do you get the impression that the Maths difficulty is part of a general low ability, or might you expect perhaps a better performance in some other subjects?

(Part 3: Comparing and contrasting pupils with Maths difficulties)

We've talked about a number of your pupils separately. Now please think of them together, and think about whether their difficulties seem to fall into similar categories, or whether seem different in distinctive ways?

(3.1) Firstly, then, any patterns of common features: are there any types of difficulties shared by all or most of them? (if so, what are they?)

(3.2) Secondly, any patterns of differences: do the pupils' difficulties we've talked about seem to fall into any rough groupings, so that a pupil with difficulties seems to fall into one or another of these groupings? (if so, what are they?)

(Part 4: Specific difficulties)

As I said at the start, the whole project is looking at 'specific learning difficulties' - that means difficulties like dyslexia, where people have serious and unexplained problems in just one part of their abilities. Maybe there might be something similar that can affect people's ability to handle numbers, or certain areas of maths.

(4.1) Firstly, dyslexia itself: sometimes a difficulty in Maths may be caused by a dyslexic-type difficulty with reading or writing. Have you ever been told of a pupil you teach having such a difficulty, and if so, how did it seem to affect the pupil's maths?

(4.2) Secondly, then, a similar kind of difficulty in Maths. The idea of dyslexia is quite well known: an unexplained difficulty with reading or writing in a someone who might be expected to do better. Do you think there may be a similar syndrome in mathematical aptitudes, where a pupil's Maths ability, or Arithmetic ability, may be relatively a lot lower than his or her other abilities? (if so, can you explain what makes you think this?)

(Finale:)

Well, I think that's it. It's been a very useful discussion.
Is there anything else you would like to add to it?
Thank you very much for your help.

Approximate level of performance relative to the rest of the year group:

5...excellent
(definite potential credit level)

4...above average
(probable credit/good general)

3...average
(probable general)

2...has some difficulty
(probable foundation)

1...has considerable difficulty
(foundation/no award)

Learning Difficulties in Mathematics

Interview responses

School: _____

Interviewer: _____

Interviewee: _____ MATHS / LS ____

Part 1. Maths difficulties in general

1.1 Some pupils find Maths difficult. It is sometimes seen as a difficult subject.
Why, in your opinion, is it so hard for some pupils?

1.2 Do you think that some pupils find Maths harder than they find other subjects?
(If so) Can you say why this might be the case?

Part 2: Particular pupils with difficulties in Maths

2.1 So, please consider your own S1 and S2 classes. Can you identify and give me the names of four or five pupils in each class who seem to be experiencing significant difficulties? They need not necessarily be the least able, though they may be.

2.2 Taking one of them at a time, can you now suggest what might be the reasons for her or his difficulty?
Obviously, the more detailed you can make your thoughts on each pupil, the more useful the data will be.

NAME

COMMENTS/POINTS

NAME

COMMENTS/POINTS

NAME

COMMENTS/POINTS

2.3 You started the interview by thinking in general terms about the reasons for Maths difficulties.
With these in mind, is there anything you'd like to add to your comments on each pupil?

2.4 For each of these pupils, can you give a rough idea of their present Maths performance compared with other pupils, by grading them on this 1 to 5 scale?

Name	5	4	3	2	1

2.5 For each of the pupils you have discussed, do you get the impression that the Maths difficulty is part of a general low ability, or might you expect perhaps a better performance in some other subjects?

Name	Probable general low ability	Perhaps better in other subjects	Don't know

Part 3: Comparing and contrasting pupils with Maths difficulties

3.1 Firstly, then, any patterns of common features: are there any types of difficulties shared by all or most of them? (if so, what are they?)

3.2 Secondly, any patterns of differences: do the pupils' difficulties we've talked about seem to fall into any rough groupings, so that a pupil with difficulties seems to fall into one or another of these groupings?
(if so, what are they?)

Part 4: Specific difficulties

4.1 Firstly, dyslexia itself: sometimes a difficulty in Maths may be caused by a dyslexic-type difficulty with reading or writing. Have you ever been told of a pupil you teach having such a difficulty, and if so, how did it seem to affect the pupil's maths?

4.2 Secondly, then, a similar kind of difficulty in Maths. The idea of dyslexia is quite well known: an unexplained difficulty with reading or writing in a someone who might be expected to do better. Do you think there may be a similar syndrome in mathematical aptitudes, where a pupil's Maths ability, or Arithmetic ability, may be relatively a lot lower than his or her other abilities?
(if so, can you explain what makes you think this?)

Finale:

Well, I think that's it. It's been a very useful discussion.
Is there anything else you would like to add to it?

NAME

COMMENTS/POINTS

NAME

COMMENTS/POINTS

Learning Difficulties in Mathematics

The school is taking part in an SED research project with Stirling University, looking at specific learning difficulties. Your help in providing information would be much appreciated.

TEACHER: _____

SUBJECT: _____

SCHOOL: _____

The pupil(s) listed below have been identified by their Maths teachers as having some difficulty in Maths, and the reasons for their difficulties have been considered in some detail.

For each, please indicate their general level of performance in your subject, relative to the rest of the year group, using this 5 point scale and ticking the box below:

5 excellent . . . . . (definite potential credit level)
4 above average . . . . . (probable credit/good general)
3 average . . . . . (probable general)
2 has some difficulty . . . . . (probable foundation)
1 has considerable difficulty . . . . . (foundation/no award)

PUPIL	5	4	3	2	1

Learning Difficulties in Mathematics

The school is taking part in an SED research project with Stirling University, looking at specific learning difficulties. Your help in providing information would be much appreciated.

SCHOOL: _____

PRINCIPAL TEACHER MATHEMATICS: _____

1. Can you describe briefly how your department delivers the Maths curriculum in S1 and S2, with particular reference to pupils with difficulties in Maths? (i.e. schemes used, class organisation, etc)

2. What do you see as the main advantages of the system you use?

3. What do you see as its main disadvantages?

4. Do ycu know of a school policy on pupils with learning difficulties?

5. If so, how does it affect the way in which your department provides for pupils with difficulties in Maths in S1 and S2?

6. How does Learning Support provide help in S1 and S2?
e.g. not at all/ extraction/ general in-class support, in-class support focused on specific pupil[s], etc)

7. Would you wish to improve your provision for pupils with difficulties in Maths, and if so, how?

8. This research is investigating the links between Maths difficulties and difficulties in other areas.

   (i) Would you expect there to be some pupils whose difficulties are in Maths and related areas only?

   (ii) Would you expect that pupils with specific language difficulties (dyslexic-type difficulties) would necessarily have Maths problems?

Thank you for providing these answers.

Please return them to _____

_____ oOo _____

Carrying out the research

Research design:

In each case study, in each school:

1, To interview Maths and LS teachers
- *to explore how they perceive and define difficulties in Maths*
- *to identify specific S1/2 pupils they teach who have Maths difficulties, and to describe these difficulties*

2, For each of these pupils with Maths difficulties, to administer a brief questionaire to their other subject teachers,
to gather data about their success in other parts of the curriculum;
- *thereby to identify any whose difficulties seem to be mainly mathematical*

3, From the resulting data
- *to analyse the original descriptions of these pupils' Maths difficulties, for any significant common features*
- *to consider the extent to which pupil difficulties with Maths seem linked to reading difficulties,*

4, By questionnaire to PT Maths
to collect data about provision made for pupils with Maths difficulties,

Procedure:

- make copies data gathering instruments

(keep note of any copying/postage costs incurred by school if wish - will be met by Stirling University)

- notify Rector of involvement if not already done so

- arrange times to interview Maths/LS colleagues, and carry out the interviews (allow ½ to 1 hour each)

- each interview will identify named pupils - extract these names, and then use the school's central timetabling information to identify all the subject teachers for each pupil.

(Guidance will be able to advise on the best way this can be done in your school; and they, or the office, may be prepared to help)

- with this information, prepare the Subject Teacher questionaires (item 3), and put them out.

(suggest pencil at top 'Please return to _____, by _____.)

- ask PT Maths to complete questionaire 4, describing aspects of the school's provision.

- collect together and despatch raw data to CW at PGS

Involvement with interviewing and data gathering

(to be completed and returned today or as soon as possible)

NAME: _____

SCHOOL: _____

Tick as appropriate

__ I wish to be involved in the data gathering stage of this research project.

__ I do not wish to be involved.

__ My input will be limited to a single interview and its follow-up questionaires to subject teachers

__ I/we hope to interview Maths/LS colleagues more extensively within the school, with follow-up questionaires to subject teachers.

Further involvement

(to be completed and returned with the raw data, or earlier if wish)

NAME: _____

SCHOOL: _____

Tick as appropriate

__ I wish to be further involved in this research project, through:

- __ considering selected samples of the interview and questionaire responses, to develop possible content analysis schemes for use in processing and categorising the raw data
- __ using these schemes to process and analyse the data
- __ considering the results and their implications
- __ considering ways of probing and exploring more thoroughly the nature of the specific Maths difficulties of identified pupils
- __ some background reading into the nature of Maths difficulties;
- __ contributing to the final research report.

__ I do not wish to be further involved.

NOTE:

Sharing the work out among small research groups will often be the best way of drawing together such geographically scattered inputs, periodically meeting and sharing ideas, together or with Stirling staff.

So, if you would like to work with particular colleagues, please indicate their names below:

_____ _____

_____ _____

_____ _____